



Original Research

Acute Specific Effects of Caffeine-containing Energy Drink on Different Physical Performances in Resistance-trained Men

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ABSTRACT

International Journal of Exercise Science 11(4): 260-268, 2018. Caffeine containing energy drink (ED) is frequently used as ergogenic aid, but its effect on performance need more investigation. Thus, the aim of this study was to analyze the effects of acute ingestion of an ED on the physical performance of resistance-trained men subjected to successive tests in the same experimental protocol. Fifteen resistance-trained males (21.0 ± 0.3 yrs; 177.4 ± 1.8 cm; 79.6 ± 1.8 kg) ingested 2.5 mg caffeine per kg of body weight (619.5 ± 14.6 mL of ED) or a placebo in a double-blind randomized cross-over design. Physical performance was randomized for the maximum repetition tests (80% 1RM) in the bench press exercise and unilateral knee extension (dominant leg), maximal isometric hand-grip test in both hands, standing long jump and repeated sprint ability test. The paired Student-t test showed that ED intake increased performance compared to the placebo for the number of repetitions in the unilateral knee extension test of the dominant leg (11.5 ± 0.9 reps vs 9.5 ± 0.8 reps; $P = 0.001$) and bench press (10.2 ± 0.4 reps vs 8.1 ± 0.5 reps; $P = 0.01$); and also increased isometric strength in the hand-grip maximal test in the right (53.7 ± 1.5 kg vs. 47.7 ± 1.6 kg; $P = 0.02$) and left hand (52.9 ± 1.5 kg vs. 45.9 ± 1.3 kg; $P = 0.02$). In conclusion, acute ingestion of ED increased performance only in specific strength tests in resistance-trained men.

KEY WORDS: Performance-enhancing substances, taurine, athletic performance

INTRODUCTION

Ergogenic resources can be defined as substances or procedures that can optimize physical performance (1). Among these resources, caffeine is one of the most frequently investigated for different physical demands, such as endurance exercise (26,31,35), strength (4,6,24), sprints (11,23) and jumps (34). In these studies, the caffeine dosage ranged from 1.5 mg per kg of body weight to almost 9 mg. The caffeine action may be linked to alterations in the central nervous system (14,30), an increase in the activity of caffeine on adenosine receptors (21), altering the plasma concentration of adenosine (13), which may result in increased recruitment of motor units (32), and mobilizing sarcoplasmic reticulum calcium through the ryanodine channels (19).

More recently, the intake of caffeine-containing energy drinks (ED) has become an option for

caffeine consumption by athletes and physically active people with a view to improving performance (17,25,29). One of the reasons for the increase in ED consumption is that, to increase the effects of caffeine, most of these beverages contain various additional ingredients to provide a synergistic or additive effect (2), such as guarana extract, taurine, amino acids, carbohydrates and vitamins (22,27).

Some studies have shown the efficacy of ED intake (\sim 200 mg caffeine) on endurance performance (60-80% of VO_{2max}) in physically active subjects (3,10,17). In high intensity, short duration effort, Del Coso et al. (15,16) investigated ED intake with 3 mg caffeine per kg of body weight on performance of football and rugby players. The authors found that ED increased the height of the jumps, ability to perform repeated sprints, total distance running during a simulated game and distance at high intensity in soccer players; and increased the overall pace of running and *sprint* movement patterns during a simulated game of rugby. In relation to resistance exercise, Forbes et al. (20) found that ED intake (2 mg of caffeine per kg of body weight) increased the total number of repetitions in three sets of exercise in the supine position (70% of 1RM), but had no effect on peak power and mean power during the Wingate test.

Regardless of the results presented by the cited studies, the effects of energy drinks on performance still need further investigation, especially when different physical demands are evaluated in the same experimental protocol. In this way, information can be gathered on which physical tests EDs have no significant effects on or if there is a superior improvement in one test over another. In this context, the objective of this study was to analyze the effects of ED intake on endurance strength, isometric strength, power and speed, in trained men.

METHODS

Participants

In order to evaluate the effects of ED consumption on performance, a double-blind cross-over randomized design was performed. Fifteen resistance-trained men participated in the present study (Table 1). All subjects were light caffeine habituated (< 250 ml of black coffee by day). The inclusion criteria were: 1) not using caffeine-based supplements 2) aged between 18-35 years; 3) having performed weight training for at least six months with a minimum frequency of twice a week. The exclusion criteria were: 1) smoking or drinking alcohol; 2) using anabolic steroids or any other ergogenic substance. All participants were instructed not to perform physical efforts on the days of data collection, have a light meal 2-3 hours prior to testing and avoid consuming beverages and foods containing caffeine for 48 hours prior to testing. The tests were performed in the afternoon, following a time pattern (12-16h). The participants were volunteers who consented to participate in the study by signing a free and clear consent form. This study was approved by the Ethics Committee for Research Involving Human Beings of the State University of Londrina under number 1.141.230/2015.

Table 1. General characteristics of the subjects (mean \pm standard deviation).

Variables	Values
Age (years old)	21.0 \pm 0.3
Height (cm)	177.4 \pm 1.8
Body weight (kg)	79.6 \pm 1.8
Training time (months)	49.7 \pm 7.7
Times per week	4.5 \pm 0.3
80% 1RM bench press load (kg)	50.6 \pm 2.3
80% 1RM unilateral knee extension load (kg)	59.0 \pm 2.7

Protocol

The study was performed over three days with a wash-out period of one week. In the first session anthropometric measurements of height and weight were conducted. Following this, the 1RM test was performed for the upper limbs in the bench press exercise (Technogym™, Rome, Italy), and the lower limbs in the unilateral leg extension (Technogym™, Rome, Italy), in the dominant leg (right leg for all). The order of the tests was random. The procedure began with a warm up of 10 repetitions with 50% of the load to be tested. After 3 minutes, the actual test began. The participants were asked to perform two complete and correct repetitions. Each individual was allowed up to 5 attempts to perform a single correct repetition of the exercises with a 3 to 5 min recovery interval between attempts. The maximum load was found on all participants in the first session of the study.

In the second and third sessions, testing with ED or a placebo was performed. On both days, the subjects arrived at the location of data collection and were randomly provided with ED or a placebo. The subjects waited at rest for a period of 60 min to allow the action of the beverage to occur. After this phase, the subjects performed the maximum repetition test in the leg extension and bench press until exhaustion, the hand grip in both hands, a repeated sprint ability test and three jumps in the standing long jump test. The execution order for each subject was randomized. There was a 5 minute rest interval between each test and at the end of each test the individuals assigned a value on the OMNI scale from 1 to 10 (28).

Ingestion of energy drink or placebo: The ED was made up of soda water, taurine (800 mg/200 mL), caffeine (64 mg/200 mL) glucoronolactone (48 mg / 200 mL), inositol (40 mg / 200 mL), natural extract of guarana and vitamins (B3, B5, B2, B6, B12). The placebo (same milliliters than ED) was made up of soda water, sugar and artificial guarana flavoring. The ED or placebo was randomly administered at two moments, at a quantity of 2.5 mg caffeine per kg of body weight. The experimental protocol was initiated 60 min after ingestion of the drinks. The principle nutritional values of the total quantity of ED and placebo ingested are shown in Table 2.

Maximum repetition tests: The maximum repetition tests were performed at 80% of 1 RM. The subjects were verbally encouraged to complete as many correct repetitions until exhaustion. The test was discontinued when a repetition was not conducted correctly.

Table 2. General characteristics of the caffeine-containing energy drink and placebo (mean \pm standard deviation).

Nutritional facts	Energy drink	Placebo
Milliliters	619.5 \pm 14.6	450.4 \pm 7.5
Calories (Kcal)	286.2 \pm 2.7	290.1 \pm 1.9
Carbohydrate (g)	71.6 \pm 1.1	72.6 \pm 0.8
Caffeine (mg)	198.2 \pm 1.4	-
Glucoronolactone (mg)	148.7 \pm 2.9	-
Inositol (mg)	123.9 \pm 1.8	-
Taurine (g)	2.5 \pm 0.3	-

Hand grip test: The evaluation of maximal isometric strength in both hands was performed through a handgrip test using a digital dynamometer (Takei Kiki Kogyo, Japan) with a precision from 0 to 100 kg. The subjects remained standing, with their feet shoulder-width apart and arms outstretched, holding the dynamometer next to the body with one hand. At a signal from the evaluator, the subjects were required to perform three maximal isometric contractions for 5 s with a 30 s rest interval between attempts. The average of the values obtained from the right and left hands was calculated.

Standing Long Jump Test: The participants were positioned behind a start line marked on the floor with their feet apart and parallel (distance 10-20 cm) and their toes touching the demarcated line. In preparation for the jump, the subjects performed a shoulder extension and knee flexion simultaneously, propelling their body forward with as much speed and force as possible. After the jump, the subjects remained in position and the distance between the first contact of the heel with the ground and the line marked on the floor was measured. Three successive attempts were performed and the average of the values obtained in centimeters calculated using a tape measure.

Repeated Sprint Ability Test (RSA): The RSA was performed on a level surface with a distance of 40 m demarcated (20 m going + 20 m back). The subjects performed six sprints at the highest possible speed and, between each sprint, there was a passive recovery interval of 20 sec. Performance in the RSA was measured by total time of test execution in seconds using a handheld stopwatch.

OMNI scale: The OMNI scale is an evaluation instrument of the perceived exertion of subjects in pre-established situations, ranging from zero (no effort) to 10 (exhaustion) (28). In the present study, familiarization with the scale was performed in the first session of 1 RM, and in the other sessions it was demonstrated at the end of each test performed. At the end of each test, the participants attributed a value to the scale.

Statistical Analysis

The data normality and sphericity were confirmed by the Shapiro-Wilk and Mauchly's tests, respectively, and the data are presented as mean and standard deviation. The Student-t test for dependent samples was used to determine differences between the effects of ED and the placebo in each test individually. Subsequently, the individual values of the session with ED were converted to percentage delta relative to the placebo to verify the performance of each

subject in the different tests. Additionally, the Cohen's d effect size was used to quantify the magnitude of the differences. The level of significance was set at $P < 0.05$. Data were analyzed using the program Statistica 13.0 (Statsoft, Tulsa, OK, USA).

RESULTS

Table 3 shows the results of the tests with the ED or placebo. It was found that the intake of ED caused greater performance in the unilateral knee extension, bench press and isometric handgrip in both hands. No significant differences were identified for the standing long jump test or repeated sprint ability. Table 3 also shows the percentage of performance values in the ED session compared to the placebo session and the Cohen's d effect size. The Cohen's d effect size was "very large" in all tests with significantly difference. The RSA test also presented "very large" effect size, but with a negative value, suggesting higher values (but with no significant effect) in the placebo session.

Table 3. Results of different physical tests after caffeine-containing energy drink or placebo intake (mean \pm standard deviation).

	Placebo	ED	$\Delta\%$	P value	Cohen's d	Classification
Unilateral knee extension (reps)	9.5 ± 0.8	$11.5 \pm 0.9^*$	+ 21.1	0.001	2.35	very large
Bench-press (reps)	8.1 ± 0.5	$10.2 \pm 0.4^*$	+ 25.9	0.01	4.64	very large
Hand-grip test (right hand) (kg)	47.7 ± 1.6	$53.7 \pm 1.5^*$	+ 12.6	0.02	3.87	very large
Hand-grip test (left hand) (kg)	45.9 ± 1.3	$52.9 \pm 1.5^*$	+ 15.3	0.02	4.98	very large
Standing long jump test (cm)	220.2 ± 8.3	224.3 ± 8.1	+ 1.9	0.08	0.49	small
Repeated sprint ability (s)	171.5 ± 0.7	169.4 ± 0.6	- 1.2	0.12	3.22	very large

ED = Caffeine-containing energy drink

Table 4 presents the values of the OMNI scale from the exercise sessions performed after ingesting ED or the placebo. No significant differences were identified between the values of the sessions. The Cohen's d effect size was "medium" or "insignificant" for all tests.

Table 4. OMNI scale values after different physical tests (mean \pm standard deviation).

Caffeine-containing energy drink	Placebo	P value	Cohen's d	Classification
Unilateral knee extension	9.2 ± 0.2	0.14	0.5	medium
Bench-press	9.1 ± 0.3	0.93	0.0	insignificant
Hand-grip test (after both hands)	8.2 ± 0.4	0.09	0.57	medium
Standing long jump test	6.2 ± 0.4	0.11	0.56	medium
Repeated sprint ability	9.3 ± 0.3	0.57	0.39	small

DISCUSSION

The main objective of this study was to examine the acute effects of ED intake, in the proportion 2.5 mg of caffeine per kg of body weight, on the performance of different physical tests in trained men. The intake of ED significantly increased performance in the unilateral knee extension exercises, bench press and isometric strength in the handgrip test in both

hands. There were no differences in the standing long jump test or RSA, and there was also no difference in the values of the OMNI scale between sessions.

To our knowledge, the present study was the first to analyze different physical demands after the ingestion of caffeine-containing ED. Our results agree, in part, with a recent meta-analysis on ED and performance (33). In this meta-analysis, the authors identified that ED increases performance in strength exercises and jumping, but not in sprinting. However, the sample consisted of athletes in several studies included in this meta-analysis (especially regarding to jumping and sprinting).

In this sense, one hypothesis for the increases in performance in the present study is the training status of the sample. The average period of training of the participants was approximately 4 years of resistance training. In this type of training, it is common to conduct exercises such as the bench press and knee extension. In addition, it is necessary to perform manual grips in many of the upper body exercises. On the other hand, actions such as jumping and repeated sprints are not usual in resistance training routine, being more specific to some sports. In this context, it is possible that caffeine-containing EDs have a specific effect depending on the type of muscle action that is evaluated. For example, the action of caffeine on performance may be related to better intra and inter muscle coordination during contraction, mediated by better recruitment of motor units (8). This mechanism, being of an acute nature, tends to be more efficient in the muscle groups and muscle actions that the sample subjects are familiar with through training (9). Thus, in the present study, even if the ED would have allowed more efficient muscle stimulation to perform the jumps or repeated sprints, the subjects were unfamiliar with such movements, and therefore did not achieve a better result. This fact can be seen in the results in Table 3, in which the individual percentage performances were close to zero for the jump and RSA tests.

However, the effects of ED on performance are still divergent in the literature and are not necessarily dependent on training state. In the present study, for example, it is important to note that the percentage increase in performance was higher in the bench press in comparison with the unilateral knee extension and the hand-grip test. In the study by Eckerson et al. (18), the authors found no increase in performance in a single series to exhaustion at 70% of 1RM in the bench press exercise in resistance-trained men, after ingestion of 500 ml of ED without sugar (160 mg caffeine). One explanation for these results is that there might be responder and non-responder individuals to the action of caffeine. This fact was reported in the study by Astorino et al. (5), who suggested that the acute effects of caffeine on performance in resistance exercise is related to an ingestion of at least 225 mg of caffeine per day; as subjects who ingest a smaller quantity will present improved performance. However, in the present study we cannot say that the individual response to the action of caffeine justifies our results, since the number of subjects who achieved performance increases in the ED session was different between tests. Furthermore, the ED may include other ingredients, in isolation or in combination, to stimulate performance. In the other hand, there are no studies involving the isolate ED ingredients on physical performance and/or their physiological mechanisms. However,

according to a recent meta-analysis concerning ED, the improvement in performance was associated with taurine dosage (33).

Therefore, in addition to the possibility of the existence of responder and non-responder individuals to the action of caffeine, we can also assume that there are responders and non-responders to other ED ingredients. This could explain, at least in part, some of the conflicting results found in studies on ED and performance.

Regarding the perception of effort, no changes induced by the ED intake were observed. That is, even though performance increased in some tests, the perceived exertion was unchanged. In this case it is suggested that caffeine, although not diminishing the perception of effort, can maintain the perception of effort at levels equal to the placebo while performing a greater effort, as found in other studies (7,12).

Although we consider our results to be important, a limitation of this study should be mentioned. The fact that the subjects ingested approximately 600 ml of ED could have caused some discomfort or queasiness, which was not analyzed by the researchers. However, there were no reports from the participants of complications following the intake of ED or the placebo.

The ingestion of 619 ± 14.6 ml energy drink (2.5 mg caffeine per kg of body weight) was effective in raising performance in the unilateral knee extension exercise and bench press until exhaustion with an 80% 1RM load and also the maximum isometric force in the hand-grip test. Our results may support in understanding the effect of ergogenic aids when different performances are required. However, it cannot be stated whether these results would be repeated in other exercises or in samples with different levels of training.

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